A PLEISTOCENE MANGANESE DEPOSIT NEAR GOLCONDA, NEVADA.[1]

THE LOCATION OF THE DEPOSIT.

GOLCONDA is a small settlement in northern Nevada, in the valley of the Humboldt river, on the line of the Central Pacific Railroad. A deposit of manganese ore occurs about three miles northeast of the town, on a part of the Havallah Range locally known as the Edna Mountains, and a short distance south of where the Humboldt river has cut its channel through the range. The deposit is small and of no great commercial value, but it is of interest both in the nature of the ore and in its geologic relations.

THE NATURE OF THE ORE.

The ore is a massive, black, glossy oxide of manganese with a hardness varying from 3 to 4. It is generally of a more or less porous structure, often containing cavities lined with mammillary or stalactitic forms, and it sometimes shows apparent signs of bedding. In places it is soft, earthy and pulverulent and contains angular fragments of sandstone, shale and limestone from a small fraction of an inch to several inches in diameter. Sometimes it is stained brown by iron.

The following analysis by R. N. Brackett, Chemist of the Geological Survey of Arkansas, shows the composition of a specimen of this ore dried at 110°-115° Centigrade.

Analysis of Manganese Ore from near Golconda, Nevada.

Manganese protoxide (MnO) - -	65.66
Oxygen (O) - - - -	10.31
Ferric oxide (Fe_2O_3) - - -	3.32

[1] This deposit was examined by the writer while investigating the manganese resources of the United States and Canada for the Geological Survey of Arkansas, and was first described in Vol. I. of the Geological Survey of Arkansas for 1890, J. C. Branner, State Geologist, R. A. F. Penrose, Jr., Assistant Geologist.

Alumina (Al_2O_3)	0.34
Cobalt oxide (CoO)	(not determined)[1]
Lime (CaO)	3.44
Baryta (BaO)	5.65
Magnesia (MgO)	1.26
Potash (K_2O)	0.35
Soda (Na_2O)	none.
Phosphoric acid (P_2O_5)	none.
Tungstic acid (WO_3)	2.78
Silica (SiO_2)	1.70
Water and organic matter	4.16
	98.97

Metallic manganese	50.85
Metallic iron	2.32
Metallic tungsten	2.20

It will be seen by the analysis that the ore is an impure oxide of manganese, being possibly a mixture of the peroxide and sesquioxide, though the impurities obscure its true nature. The most remarkable feature of the ore is the considerable amount of tungstic acid present, comprising 2.78 per cent of the ore and corresponding to 2.20 per cent of metallic tungsten. The form in which the tungsten exists in the ore is uncertain. It is possible that it may exist as a tungstate of manganese or iron, or of both, or perhaps of one of the other bases present. It may either have been deposited from solution with the manganese, or it may have been brought in as detritus from an outside source during the deposition of the ore, in the same way as the fragments of rock were brought into the deposit.

Though from a mineralogical standpoint the ore is impure, yet for commercial purposes the analysis shows a good grade of manganese ore, and the presence of the tungsten would give additional value to the ore in the manufacture of certain kinds of hard steel.

THE NATURE OF THE DEPOSIT.

The ore occurs as a lenticular deposit imbedded in a soft white or buff colored calcareous tufa which contains fragments of sandstone, shale and massive limestone similar to those found

[1] There is more than a trace of cobalt present but the amount was not determined.

in the ore and often in sufficient quantities to form a breccia. This material composes a small knoll on the lower slope of the mountain, and lies on the upturned edges of underlying shale. The association of the manganese and the tufa is shown in Figure 1, while the relation of the deposit as a whole to the Edna Mountains is shown in Figure 2. The first figure represents the small knoll on the left hand side of the second figure.

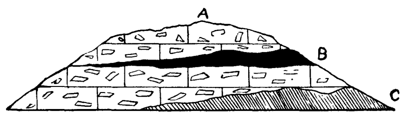

FIGURE 1.—*Section through the Golconda manganese deposit.*

A. Calcareous tufa. B. Manganese ore. C. Shale.

Horizontal scale: 1 inch = 125 feet. Vertical scale: 1 inch = 80 feet.

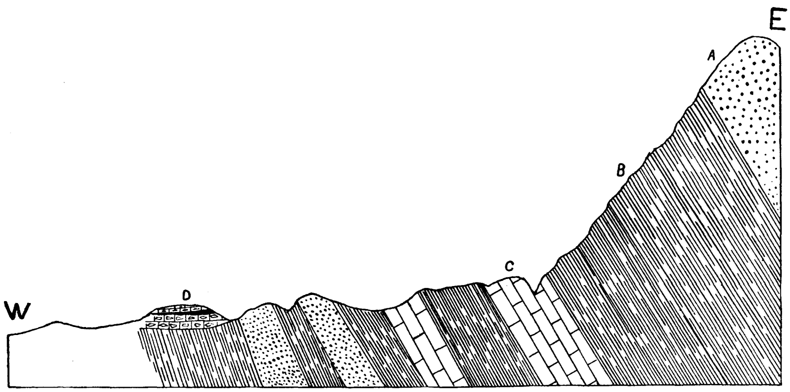

FIGURE 2.—*Section showing the relation of the Golconda manganese deposit to the rocks of the Edna Mountains.*

A. Quartzite. B. Shale. C. Limestone. D. Manganese-bearing deposit.

Horizontal scale: 1 inch = 500 feet. Vertical scale: 1 inch = 300 feet. (Both of these scales are only approximations.)

The outcrop of the ore bed appears as a horizontal black band along the side of the knoll facing the mountains, and is very variable in thickness, in some places being represented only as a black line in the white material enclosing it and in others

widening to a maximum, where exposed, of three and a half feet. On the west slope of the knoll the ore bed is not seen at all, the only trace of it being an occasional black stain or dendrites in the limestone along the line where it should outcrop if it extended through to this side. The bed also thins out to the north and south, the whole length of the outcrop being only about 400 feet. East of the outcrop of the ore, the knoll is cut sharply off, as shown in Figure 2, by a rocky area which separates it from the mountains. It will thus be seen that the amount of ore here is limited, and it is probable that the area underlain by it does not cover more than a few acres.

Beneath the ore bed, as seen in one of the small pits that have been made on the deposit, the calcareous material is soft and partakes of the nature of a marl, while above, it is often much harder and has in many places become coarsely crystalline. The crystillization seems to have taken place in spots in the bed, and frequently bodies of crystalline material are surrounded by, and blend into a massive and softer tufa of the same composition.

The fragments of sandstone, shale and gray limestone found in this deposit are of the same nature as the beds of those rocks which comprise the mountain to the east and are undoubtedly derived from them. The pieces of limestone are so markedly different from the calcareous bed enclosing them that they cannot be confounded with it. The rock fragments are of unequal distribution in the deposit, both laterally and vertically, sometimes composing almost half of it, and sometimes being almost entirely absent. They vary from a fraction of an inch to several inches in diameter and are indiscriminately mixed.

The age of the rocks composing the part of the Havallah Range lying east of the manganese deposit is represented as Star Peak Triassic on the map accompanying the Survey of the Fortieth Parallel.[1] As shown in the section given above they are

[1] U. S. Geol. Exploration of the Fortieth Parallel; Clarence King, Geologist in charge; Vol. I., Systematic Geology, map III., Pre-Mesozoic and Mesozoic Exposures. See also report ot Arnold Hague, Vol. II., Descriptive Geology, page 680.

composed of sandstones, shales and limestones dipping at steep angles. The upturned edges of the rocks are well exposed from the summit of the mountain to its base, where they are covered by the small knoll or mound containing the manganese deposit.

The crest of the mountain is composed of a quartzite which is of a dark gray color, spotted with brown specks, of a granular structure, very hard and cut by numerous quartz veins. The lower beds of quartzite on the slopes resemble this one in all respects except that they show less trace of their original sandy structure and are more vitreous. The larger part of the slope of the mountain is composed of a more or less slaty shale. It is of a gray or purple color, contains large quantities of thin flakes of mica, has a wavy, undulating structure and in some places grades almost into a micaceous or talcose schist. The lower beds of shale are much thinner than this one, and in some places resemble it in general appearance, while in others they are more calcareous and blend into limestone. The shale which underlies the knoll containing the manganese (see figures) is of a light yellow color on its surface exposure, and is made up of thin friable laminæ. The limestone beds shown in Figure 2 are all of much the same character; they are of a light or dark gray color, sometimes with a reddish tinge, generally massive, though occasionally showing a tendency to a semi-crystalline structure, and are frequently cut by veins of white crystalline calcite.

THE ORIGIN OF THE DEPOSIT.

The Golconda manganese deposit is in the arid region lying between the Rocky Mountains and the Sierra Nevada, and known as the "Great Basin." Parts of this region, as is well-known, were, in Pleistocene, or Quaternary, times covered by several large inland bodies of water, of which lakes Bonneville and Lahontan, described respectively by G. K. Gilbert[1] and I. C. Russell,[2] were the largest. In subsequent times these were

[1] Lake Bonneville, Monograph U. S. Geological Survey, No. 1., 1890.

[2] Geological History of Lake Lahontan, A Quaternary Lake of Northwestern Nevada, Monograph U. S. Geological Survey, No. XI., 1885.

mostly dried up, and the only remains of them now are a series of much smaller lakes, occupying hollows in the bottoms of the old lake basins. Great Salt Lake is the modern representative of Lake Bonneville; and Tahoe, Winnemucca, Pyramid and other lakes occupy the basin of Lake Lahontan.

The region about the manganese deposit is on the eastern edge of the area defined by Mr. Russell as the ancient bed of Lake Lahontan, and occupies a position at the head of what was once a small bay protruding about fifteen miles up what is now the valley of the Humboldt River. Mr. Russell,[1] in speaking of the lakes which formerly existed in the Great Basin, says: "Some of these old lakes had outlets to the sea, and were the sources of considerable rivers, others discharged into sister lakes; a considerable number, however, did not rise high enough to find an outlet, but were entirely inclosed, as is the case with the Dead Sea, the Caspian, and many of the lakes of the Far West at the present time." Lake Lahontan did not overflow, and, therefore, the mineral matter brought to it in solution by tributary waters constantly increased in quantity; while the gradual evaporation of the lake steadily concentrated these mineral solutions until they arrived at a state of supersaturation, and were deposited as chemical precipitates. These were, according to Mr. Russell, largely of a calcareous nature, and were laid down as fringes on the margin of the lake at successive stages of evaporation. They are found now at different levels on the old lake border, and mark the ancient shore lines. Mr. Russell has divided them into three classes of "tufas," differing considerably in physical character, and deposited at different levels during the desiccation of the lake. He has named them in the order of their chronological succession, "lithoid," "thinolitic," and "dendritic" tufas. From the analogy of the samples of tufa collected by the writer at the manganese deposit with the description of lithoid tufa given by Mr. Russell, and from the position that the deposit occupies in the old Lake Basin, it is probable that

[1] Geological History of Lake Lahontan, A Quaternary Lake of Northwestern Nevada, Monograph U. S. Geological Survey, No. XI., 1885, page 6.

the calcareous material with which the Golconda manganese deposit is interbedded represents the lithoid tufa of Russell, and that the manganese itself is a local deposit not necessarily characteristic of the variety of tufa with which it is associated. In other words, the deposit represents a lenticular bed of manganese ore interstratified with a calcareous sediment, the latter having been chemically deposited from supersaturated lake waters. It will be seen in Fig. 2 that the manganese deposit occupies a basin in this tufa, that the basin was originally cut off on the east side by the rocks that formed the old shore line, and that it was bounded on its west side by the outer edge of the tufa terrace. Between these limits it extended a short distance up and down the lake shore. This position, as well as the nature of the ore, both tend to show that the bed was originally laid down as a shallow water deposit and subsequently covered over by a tufa similar to that which underlies it.

It seems possible that the origin of the ore deposit was a local accumulation of manganese precipitated from spring waters. In support of this supposition it may be stated that at the town of Golconda there are, at the present time, a series of hot springs depositing a sinter highly charged with oxide of manganese. The source of this manganese in the spring waters may have been in the igneous rocks which cover large areas in the region in question, and give strong reactions for manganese. Another possible source of supply may have been in the stratified rocks already described as forming the mass of the mountain on the slope of which the deposit is situated, as both the quartzite and the limestone contain small quantities of manganese. The igneous rocks, however, contain a larger percentage of this material than the other rocks.

As regards the mode of precipitation of the manganese, it is not probable that the ore was deposited simply by the gradual desiccation of the lake waters, as was the case with the lithoid tufa enclosing it, since, if this had been so, a far more general distribution of manganese than is seen in the tufa of the Lahontan basin would be expected. It seems more probable that the

deposit was due to a local precipitation brought on by an excess of manganese in spring waters in the locality in question, and that the cause of its accumulation was the accidental formation of a suitable basin in the tufa. This basin may either have been closed or may have had an outlet into the lake. When the spring waters reached the surface they were probably retained, at least temporarily, in the basin, long enough to allow the oxidation of the metalliferous solution and the precipitation of oxide or carbonate of manganese,[1] thus causing a local accumulation of ore; whereas, if the spring water had flowed directly into the lake, its contents of manganese would have been scattered over a vast area, and would not have accumulated anywhere in deposits of noticeable size. The rock fragments in the ore and tufa represent detritus from the mountain side carried down during the deposition of the beds.

The deposition of manganese by spring waters elsewhere than in the case in question, though in limited quantities, is not an unusual occurrence. The Hot Springs of Arkansas deposit a calcareous sinter often heavily impregnated by manganese. A hot spring near the Cape of Good Hope,[2] with a temperature of 110° Fahrenheit, deposits oxide of manganese in its discharge channel. A mineral spring in the house of the Russian Crown, at Carlsbad,[3] with a temperature of 68° Fahrenheit, also forms manganiferous deposits. The springs at Luxeuil,[4] as well as the waters in some of the mines at Freyberg,[5] also form manganiferous sediments. These deposits, however, are all very small and are simply mentioned to show the frequent occurrence of manganese deposited by springs. Cases where a black incrustation of oxide of manganese is deposited by rivers and creeks on the rocks and pebbles in their courses are of common occurrence.

R. A. F. PENROSE, JR.

[1] If the carbonate was precipitated, it was later converted by oxidation into its present oxide form.

[2] Townsend, l' Institut., 1844, No. 529. (Bischof.)

[3] Kersten's u. v. Dechen's Archiv. f. Mineral., etc., Vol. XIX., p. 754. (Bischof.)

[4] Braconnot, Ann. de Chim. et de Phys., Vol. 18, p. 221. (Bischof.)

[5] Kersten's u. v. Dechen's Archiv. f. Mineral., etc., Vol. XIX., p. 754. (Bischof.)